WIND SPEED MEASURING SYSTEM, FREQUENCY TYPE

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ABSTRACT

A variable frequency wind measuring system, developed to permit telemetering of wind speed information over great distances, is described. A cup-rotor sensor drives a cylindrical slotted shutter, which in rotating interrupts a light beam falling upon a photocell. The electrical signal from the photocell, after amplifying and shaping, may be used as a telemetering signal or to control telemetering signals.

1. INTRODUCTION

The direct indicating type of wind speed measuring system in general field use by the Weather Bureau consists primarily of a cup-rotor sensor which drives a d.c. magneto, with the output current of the d.c. magneto supplying a signal to milliammeter type indicators. The wide-angle (250°) scale milliammeter is calibrated so that indication of the wind speed is in nautical miles per hour. Where required a suitably calibrated milliammeter graphic recorder may be used to obtain a record of the variability of the wind speed. Because of the relatively low resistance (428.6 ohms) of the indicator network this type of system is not suited for operation of the sensor at very great distances from the indicators. A connecting circuit resistance of 4.7 ohms would reduce the indicated values by about 1 percent. Repeating amplifiers of the magnetic type may be used, but they are limited to direct wire circuits. To facilitate telemetering of wind speed information a variable frequency type of wind speed measuring system has been developed.

2. TRANSMITTER

The wind speed transmitter is considered primarily to comprise a cup-rotor sensor, and a shutter and photocell assembly. The cup-rotor sensor is identical to that used with the d.c. magneto generator type system. The cup-rotor is composed of three cups 4.45 inches in diameter supported on arms with the cup centers lying in a plane on 6.313-inch radii. The cups are approximately conical in form and have a rolled or beaded edge. Tests performed at various times at the National Bureau of Standards wind tunnel indicate that the ratio between the wind speed in nautical miles per hour and the revolutions of the cup rotor per second is a constant, the value of which is very nearly 5.22. It is desirable that there be an integral relationship between the generated pulses per second and the wind speed in knots. By generating 26 pulses for each cup-rotor revolution and then sending the pulses through a divide-by-five circuit, an output value of 5.2 pulses per revolution of cup-rotor is obtained. For correct indication of wind speed a cup-rotor rate of 10 revolutions per second should give an indicated wind speed value of 52.2 knots. Using a 26-slot shutter a value of 52.0 knots is obtained, which is within 0.5 percent of the theoretical value. Hence, by using the 26-slot shutter and a divide-by-five circuit, very nearly a 1 to 1 correspondence is obtained between the generated pulses per second and the wind speed in knots.

The physical achievement of 26 pulses per revolution is obtained by using a cylindrical shutter, about 1 inch in diameter, which is attached to and driven by the cup-rotor shaft. The cylindrical shutter has 26 vertical slotted openings which permit the passage of light to

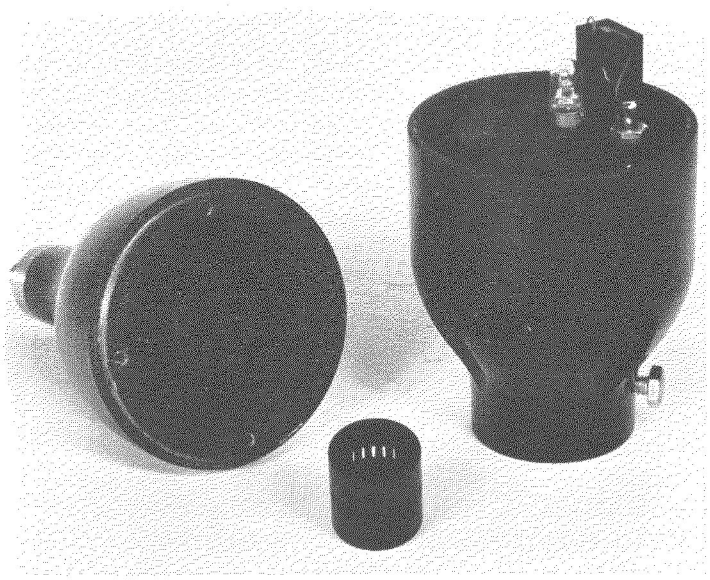

FIGURE 1.—Wind speed transmitter, disassembled, with extra shutter.

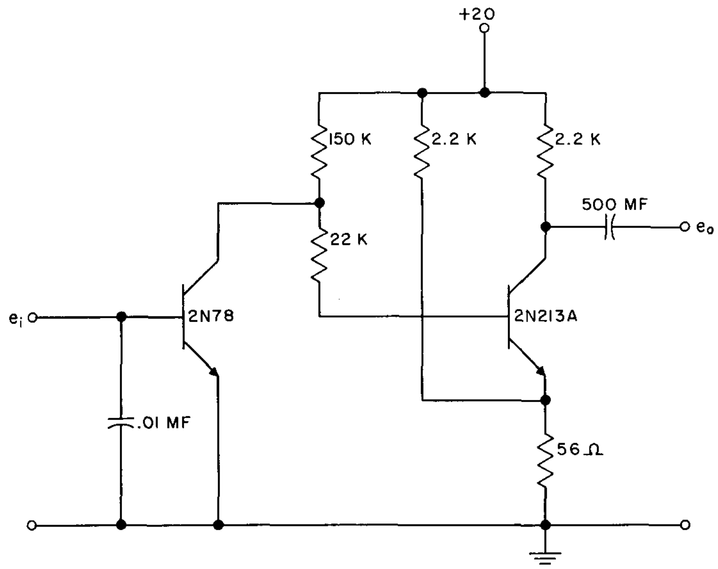

FIGURE 2.—Circuit of signal amplifier, switching type.

a photocell (see fig. 1). A type 44 lamp, having about 5 volts, d.c., applied to it, is located within the shutter and serves as a light source for the photocell. The lowered lamp voltage permits a life expectancy of at least 1 year. The photocell, consisting of a 0.5 by 1 centimeter silicon cell, is located outside of and close to the shutter. Each pulse of light falling upon the photocell causes the generation of a pulse of current. The silicon type cell was selected because it will operate over large ranges of ambient temperature and it also has a relatively low internal impedance, suitable for driving transistorized devices.

3. AMPLIFIER

The voltage output level from the photocell is approximately 0.1 volt, and of insufficient power to serve as a direct signal source. To bring the signal to a sufficiently high level, a two-stage transistor amplifier of the switching type is used. The circuit for the amplifier is shown in figure 2. Under no-load condition, the output voltage level shift exceeds 12 volts. A well filtered and regulated power supply of 20 volts is required for this amplifier. Tests indicate that the transistors used in this amplifier are suited for operation under most ambient temperatures likely to be encountered in normal field use.

The frequency range for the output of the transmitter is from 5 to 750 pulses per second corresponding to a speed range of from 1 to 150 knots. By using a divide-by-five circuit at the transmitter site, the frequency range of the telemetered signal will be from 1 to 150 pulses per second. The lower frequency range may be more suited for use where a narrow band audio tone carrier is used. Where direct circuit connection may be used, the divide-by-five circuit may be more conveniently placed at the indicator location.

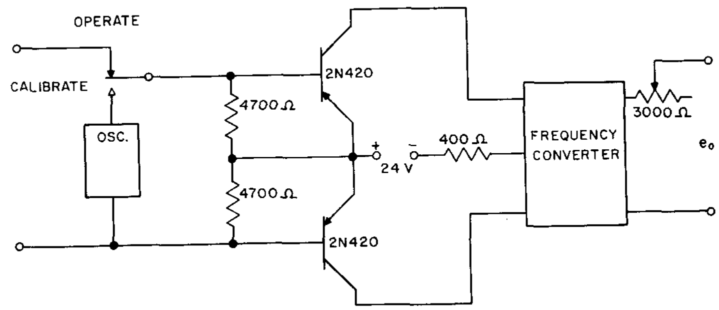

FIGURE 3.—Circuit of power amplifier to drive frequency converter.

4. INDICATORS

Either digital or analog type of display may be used with the variable frequency wind speed measuring system. For an analog display, such as the milliammeter type in present use, it is necessary to use a simple stable frequency to analog converter. The small magnetic saturable-core type of converter seems well adapted to this purpose. The application of excess power is required for the proper operation of the converter, so it is necessary that a power amplifier be used to drive the converter. The circuit of a power amplifier that has been used for this purpose is shown in figure 3. For calibration of the indicators a known frequency may be inserted, from a stable oscillator, in place of the signal frequency. The calibration frequency can be either 400 cycles per second or 80 cycles per second, depending upon whether or not a divide-by-five circuit is being used, to give a check calibration point of 80 knots.

For digital display indication, a counter using a fixed time base may be used. The counter will show the average of the sample over the selected time base which can be as desired, anywhere from say 1 second to 1 hour or 1 month, etc. For sampled readings using a 1 second time base it is advisable to add a value of 1 knot to compensate for dropped fractional values and frictional loading. One-second sample readings may be stored over a period of 10 minutes, with the highest sample value being selected and compared with a 10-minute average sample to obtain a measure of the variabilty of the wind speed.

To obtain integrated values of wind passage a preset counter can be used to supply contact closures. Using the frequency rate obtained after the divide-by-five operation, a counter preset to 3,600 with relay output will give contact closures for each nautical mile passage of wind. If one-sixtieth knot contact closures are desired, the counter should be preset to 60. The contact closures may be used to operate a numerical indicator or recorder to show the total wind passage per day, per hour, etc.

5. CONCLUSIONS

Several advantages may be gained from using a variable frequency wind speed measuring system, such as described, some of which come about indirectly. The primary advantage, for which the system was designed, is ease of telemetering. Signal transmission losses may be compensated for by using frequency amplifiers without loss of information. The variable frequency signal is well suited for input to automatic meteorological observation systems, particularly those types using computer components. The cup-rotor starting speed is reduced from about 4 knots to less than 1 knot, by elimination of brush and commutator friction, iron core losses, and magnetic drag. This, of course, presupposes that the bearings of the transmitter are in good condition. By the elimination of the commutator and brushes used in present equipment, a considerable gain in the stability and accuracy of the wind speed signal can be attained over long periods of time. Thus, the maintenance requirements of the transmitter are reduced, with the elimination of calibration of the transmitter. In many instances annual servicing should suffice. Also, due to the smaller and lighter-weight components required, a smaller and much lighter-weight transmitter case may be employed. In addition, with this unit considerable additional climatological information will be available for low wind speeds.